UNCLASSIFIED

AD NUMBER

AD322568

CLASSIFICATION CHANGES

TO: unclassified

FROM: confidential

LIMITATION CHANGES

TO:

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FROM:

Controlling DoD organization: Naval Ordnance Lab., White Oak, MD.

AUTHORITY

31 Jan 1973 per DoDD 5200.10; Naval Ordnance Lab ltr dtd 29 Aug 1974

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AD 322 568

THE EFFECT OF COMPOSITION AND DENSITY ON THE

SENSITIVITY AND THE OUTPUT OF DATB AND DATB/ZYTEL (95/5) (U)

15 JANUARY 1961

U. S. NAVAL ORDNANCE LABORATORY

WHITE OAK, MARYLAND

CONFIDENTIAL

THE EFFECT OF COMPOSITION AND DENSITY ON THE

SENSITIVITY AND THE OUTPUT OF DATB AND DATB/ZYTEL (95/5) (U)

Prepared by:
J. N. Ayres

Approved by: _____

Chief, Explosion Dynamics Division

ABSTRACT: The sensitivity, output, and density of pure DATB and DATB/Zytel (95/5) have been studied in the small scale gap test for consolidating pressures ranging from 4 KPSI to 64 KPSI. The results show that composition alone is not sufficient for stating the performance of these explosives. The density of the charge has a major effect on the sensitivity and output.

NavWeps Report 7348   15 January 1961

The work reported herein is part of the effort being carried
out in an attempt to assess the booster-to-warhead reliability
of the EX-38 Warhead system. It is being carried out under
Project RM37-23003/212-1/WO20-AD-003 SPARROW III - PBX
Warhead Development and represents an application of the
VARICOMP method of studying reliability of detonation transfer.
It should be of interest to those concerned with weapon system
reliability and safety studies.

                         W. D. COLEMAN
                         Captain, USN
                         Commander

                         J. ARONSON
                         By direction

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ILLUSTRATIONS

THE EFFECT OF COMPOSITION AND DENSITY ON THE SENSITIVITY
AND THE OUTPUT OF DATB AND DATB/ZYTEL (95/5)   (U)

BACKGROUND AND OBJECTIVE

1.   DATB and DATB based compositions are coming into use as warhead explosives. Because of its newness there is inadequate information concerning the boostering requirements which must be met to assure initiation of DATB explosives in particular systems.

2.   Part of the work being carried out under the EX-38 Warhead program, by means of the small scale gap test (SSGT),[1] involves the measurement of the sensitivity of pure DATB and of DATB/Zytel* (95/5) as a function of the charge density. SSGT conditions differ appreciably from those that apply in the warhead. Other evidence is therefore necessary in order to decide whether these SSGT data are relevant. However, it was expected that SSGT data would be of considerable use in choosing charge specifications for simulated booster-warhead initiation tests.

EXPERIMENTAL

3.   The SSGT configuration, Figure 1, consists of:

(a)   A standard RDX donor, 0."2 diameter column of explosive 1."4 long pressed at 10 KPSI into a 1."0- O.D. brass body 1."5 long.

(b)   Variable thickness lucite attenuators placed between the donor and the acceptor explosive.

(c)   An acceptor containing the explosives being tested as a 0."2 diameter column 1."5 long loaded into a 1."0 - O.D. brass body 1."5 long.

(d)   A 3."0 - O.D. by 1."5 thick steel block used as a witness plate; the vigor of the acceptor explosive being reported as the depth of dent formed in the block.

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(1)   NavWeps Report 7342, Standardization of the Small-Scale Gap Test used to Measure the Sensitivity of Explosives, J. N. Ayres (To be published.)

* Zytel - A trade name for a commercial grade of Nylon.

4. Usually a single sensitivity experiment is carried out using a 50-shot go-no go Bruceton firing method.[2] In the present case, however, it was decided to explore a closely related series of conditions involving two similar explosives, each at 5 different densities. Because the data from individual points would be expected to reinforce each other, the total sample size at each point could be reduced somewhat from that usually chosen. As a matter of intuitive judgment, it was believed that the sample size could be reduced to about 40 percent of the usual. In the interests of economy and time, the total sample size was reduced from 500 to 100. (Ten shots at each of 5 densities for each of the 2 explosives.)

5. Since the total number of tests at any one set of conditions was 10 and since on the average only 5 of these were functioned (the other 5 being no-goes from the firing test method), the data for measuring output and sensitivity are sparse. Furthermore, the normal Bruceton analysis of sensitivity data cannot be applied. Special statistical techniques were used to estimate the 50 percent firing response and the standard deviation (or in some cases the maximum limit of the standard deviation).

6. Pure DATB and DATB/Zytel (95/5) were loaded; 10 pieces each at each of five densities. Since the test pieces are all of the same size and volume, the charge weight was adjusted in each instance to obtain the desired density.

7. Two parameters are needed to depict the sensitivity of an explosive -- the mean (the shock intensity required to initiate the explosive in 50 percent of the trials) and the standard deviation, s. In graphical form the mean is represented by a dot on a vertical line connecting the mean + 1s, and mean - 1s points. The sensitivity data are reported in units of DBg (gap decibang) -- a measure of the strength of the shock applied to the explosive under test. The DBg expresses shock strength relative to an arbitrary reference shock, and increases in value with increasing shock strength. A less sensitive explosive would require a stronger shock input than a more sensitive explosive and would therefore have a larger mean value. For instance: when loaded at 90 percent TMD, TNT will exhibit a 50 percent response at 5.52 DBg shocks input whereas the more sensitive RDX will have a 50 percent point of 3.77 DBg.

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(2) AMP Report 101.1R SRG-P, No. 40, "Statistical Analysis for a New Procedure in Sensitivity Experiments", July 1944. (A report submitted by the Statistical Research Group, Princeton University).

RESULTS

8. The data are given in Table 1 and shown in Figures 2 and 3. The data points are connected by point-to-point lines rather than by eye-fitted or statistically fitted smooth curves. Smooth fitted curves imply a pre-existing knowledge or opinion as to the shape of the curve that ought to express the relationship. In the present case a number of different traces of varying curvature (including straight lines) could be used without straining one's faith in the laws of nature. The proper curve to use is at present too much a matter of conjecture and opinion.

9. Previous work at this Laboratory (Naval Ordnance Laboratory, White Oak, Md.) has shown that over a limited range the density of a pressed charge is proportional to the logarithm of the consolidating pressure. Consequently the density (reported as the ratio of the observed density to the theoretical maximum density), the output, and sensitivity are plotted in Figure 2 against the log of the pressure. From this graph the general trends are clearly evident and are consistent with expectations:

(a) DATB, at a given pressure, is harder to press, is more sensitive, and has a greater output than the DATB/Zytel (95/5) composition.   *

(b) Increasing consolidating pressure increases output and density, the rate of increase gradually falling off with increasing pressure.   *

(c) Increasing consolidating pressure desensitizes the explosives. A sharp. desensitization occurs at the higher pressures. (Approximately 30 KPSI.)

10. When the data are replotted, Figure 3, on the basis of percent of theoretical maximum density, it appears that at above 92 percent TMD, the composition has little or no effect on the sensitivity, and an increased effect on the output.

----

* The DATB/Zytel composition is formed by a cold pressing operation. In explosives used in weapon systems some heat is applied to produce a bonding of the binder. It is believed that bonding will not change the sensitivity of the explosive from that which it would have in the cold pressed state. Under no circumstance will it influence the basic premise of this report - that sensitivity (and output) are highly dependent on the explosive density.

3

CONCLUSIONS

11. Since the greatest interest in the use of DATB lies in the region of 92 to 96 percent TMD and since this appears to be a region wherein the sensitivity of DATB is strongly affected by the density, it would appear that the reliability of a system could be sharply altered by a relatively small change in density. The standard deviation of many explosive systems has been found to be less than 0.05 DBg. The present set of experiments does not permit a good measurement of the standard deviation of the sensitivity data. There are reasons for believing, however, that the variability of DATB would be no greater and perhaps considerably less than the 0.05 DBg value. From Figure 3 it would appear that the mean sensitivity of a composition could be shifted eight or ten standard deviations by a change from 92 percent TMD to 96 percent TMD. Had the system been just adequately reliably at 92 percent TMD, it would in all likelihood become unreliable at 96 percent TMD.

12. The effect of the binder on the sensitivity of a DATB composition cannot be assessed unless the density also is evaluated. This is no new concept but it should not be overlooked. In future work on the EX-38 Warhead it has been decided to perform certain "penalty" tests with a further diluted DATB/Nylon (90/ 10). It may be that (provided the material can be fabricated) a 95/5 DATB/Nylon composition at a considerably high molding pressure will provide an adequately desensitized explosive to perform reliability studies on the booster-to-warhead system.

Table 1

SENSITIVITY AND OUTPUT OF DATB AND DATB/ZYTEL (95/5)

Loading Pressure (KPSI)	Density (gm/cc)	% TMD*	S of % TMD	Output Dent (mils)		Sensitivity (DBg)	
				mean	S	mean	S
DATB							
4	1.233	67.1	0.5	36.6	2.1	6.938	0.042
10	1.455	79.2	0.5	43.7	1.4	7.375	0.107
20	1.601	87.2	0.2	45.6	2.5	7.875	0.290
32	1.676	91.2	0.3	51.5	3.4	8.100	0.038
64	1.763	96.0	0.3	54.6	3.0	9.000	0.064
DATB/Zytel (95/5)							
4	1.210	68.3	0.4	33.6	2.9	7.45	0.125
8	1.366	77.2	0.1	38.7	2.2	7.74	0.032
16	1.534	86.6	0.3	41.0	4.3	8.03	0.188
32	1.657	93.6	0.2	46.4	2.9	8.46	0.120
64	1.730	97.7	0.1	49.6	3.2	9.325	0.625

* TMD - theoretical maximum density

S - standard deviation

For comparison purposes the DBg sensitivities of several standard explosives are as follows:

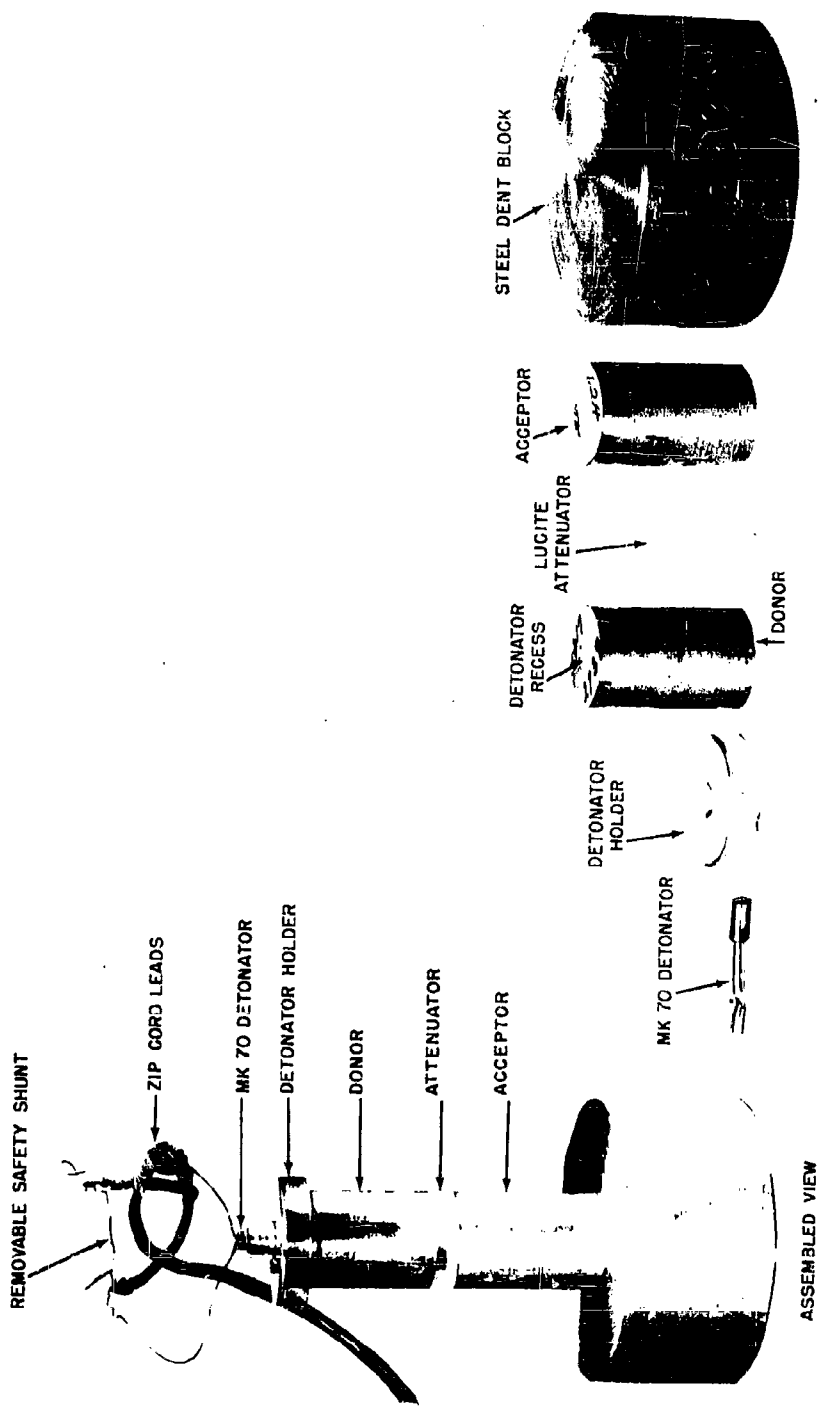| Explosive	Density (gm/cc)	% TMD	DBg
TNT (pressed)	1.48	90.0	5.52
"	1.56	94.6	6.16
CH-6	1.61	89.9	4.10
Tetryl	1.53	88.3	3.63
RDX	1.63	90.5	3.77
RDX	1.73	96.0	5.07

F'G. I   REVISED SMALL SCALE GAP TEST SETUP
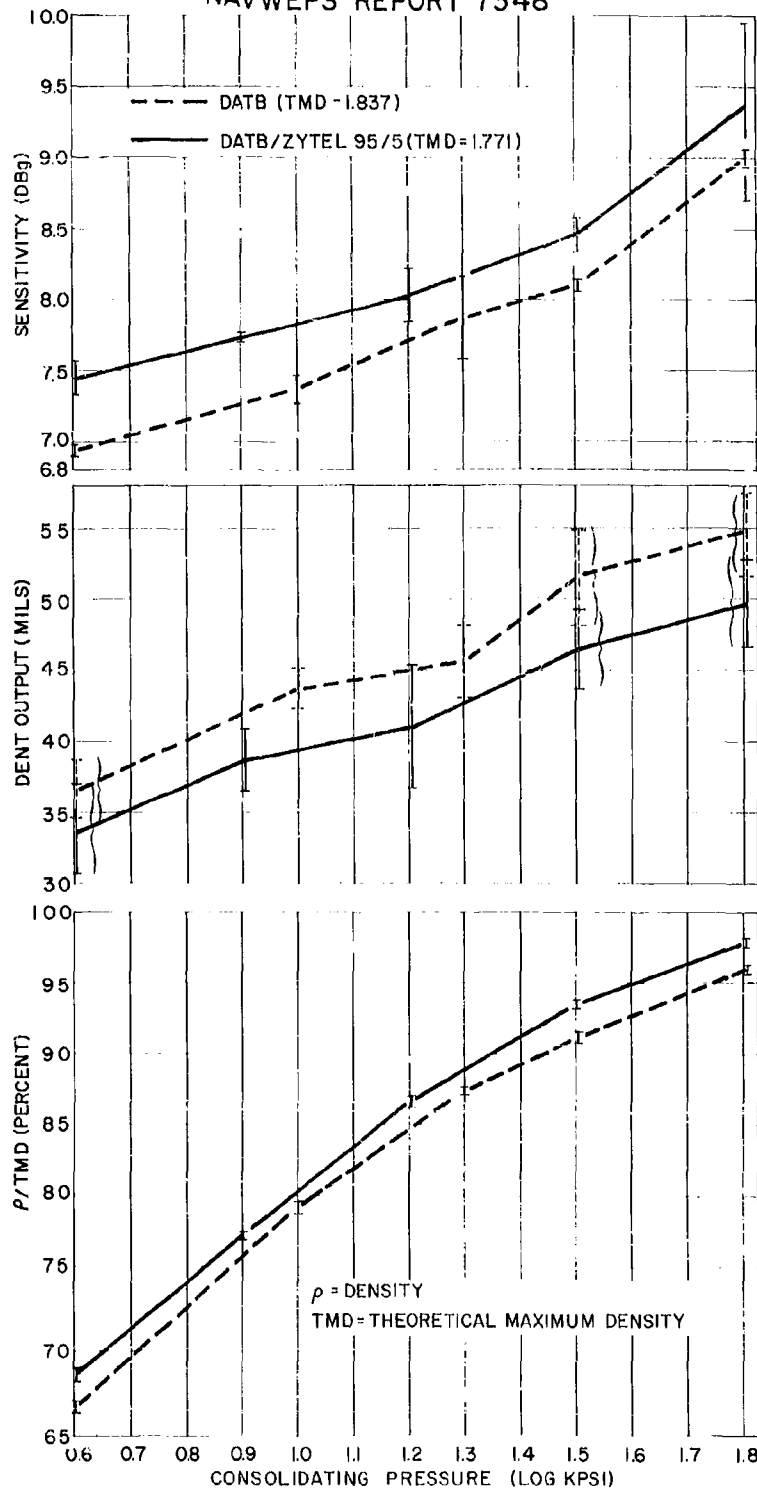
FIG. 2 EFFECT OF COMPOSITION AND CONSOLIDATING
PRESSURE ON DENSITY, OUTPUT, AND SENSITIVITY
OF DATB AND DATB/ZYTEL 95/5
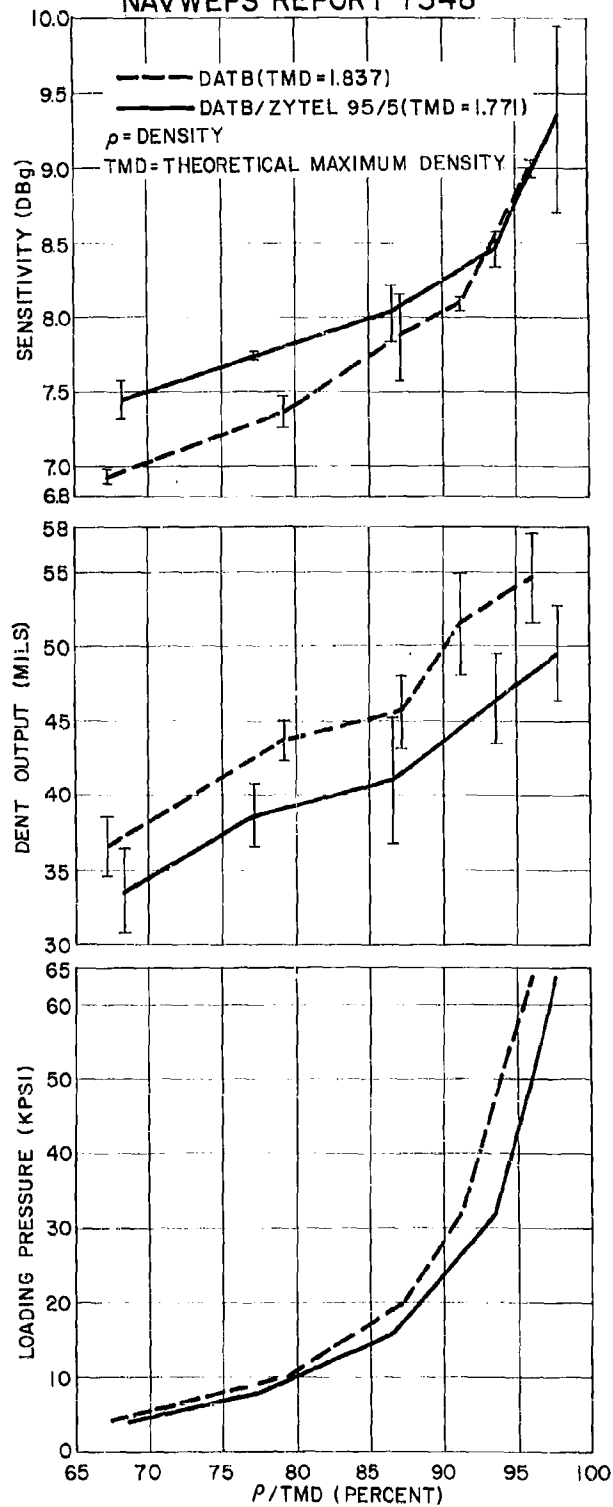
FIG.3 EFFECT OF COMPOSITION AND DENSITY ON
THE SENSITIVITY AND OUTPUT OF DATB AND
DATB/ZYTEL 95/5

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